Canada’s Improving Energy Productivity: More Than Just Energy Efficiency

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- INTRODUCTION -

Canadian fuel and electricity consumption per dollar of GDP (**E/GDP**) declined by 23% between 1995 and 2010, after remaining relatively stable for the previous decade (Fig. 1).

This improvement in energy productivity was the largest moderating influence on the growth of greenhouse gas emissions over the period. Understanding the dynamics of the E/GDP quotient can inform climate change response policies and help anticipate emerging risks and opportunities in energy markets.

We took a deep dive into the dynamics of Canada’s energy systems to better understand just how and why the decoupling came about. Energy efficiency gains are only part of the story.

Why did Canada’s GDP and energy use (E) diverge between 1995 & 2010?

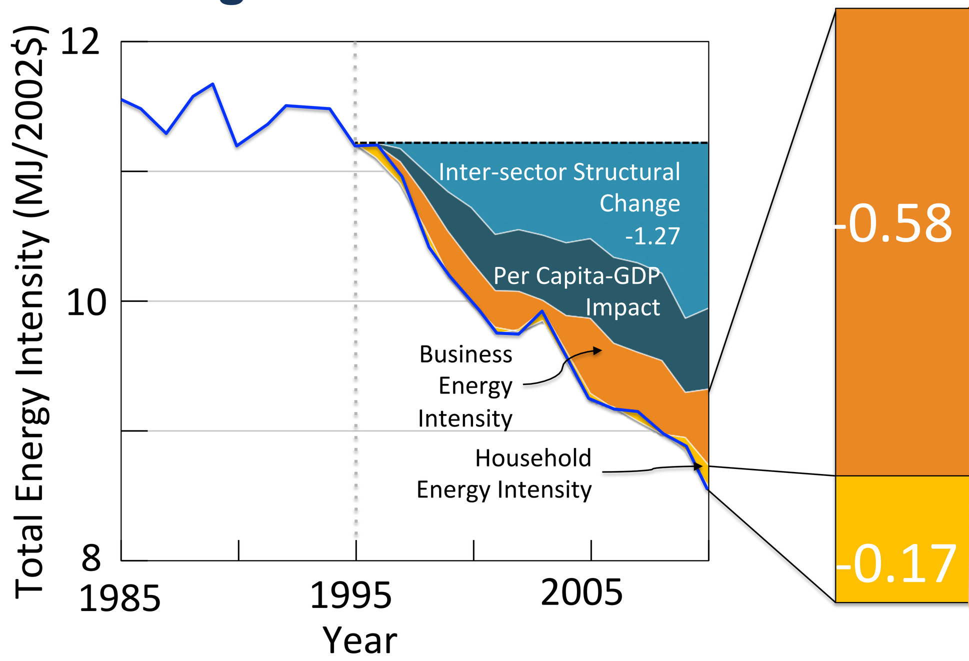


Fig. 1. Changes in key parameters of Canada’s Energy Systems

- METHODS -

We employed the Logarithmic Mean Divisia Index (LMDI) method [1] to conduct a multi-level factorization of the observed 2.64 MJ/$ decline in the primary energy intensity of the Canadian economy over the 1995-2010 period, including analyses of the contributions of efficiency and structural factors at the intra-sectoral level. Six sectors are defined for the productive economy and a database with one-to-one correspondence between GDP and E values is used to track sector intensities.[2] A separate analysis of per capita energy intensity of the household sector (residential and personal transportation) is linked the comprehensive E/GDP analysis by GDP/capita.

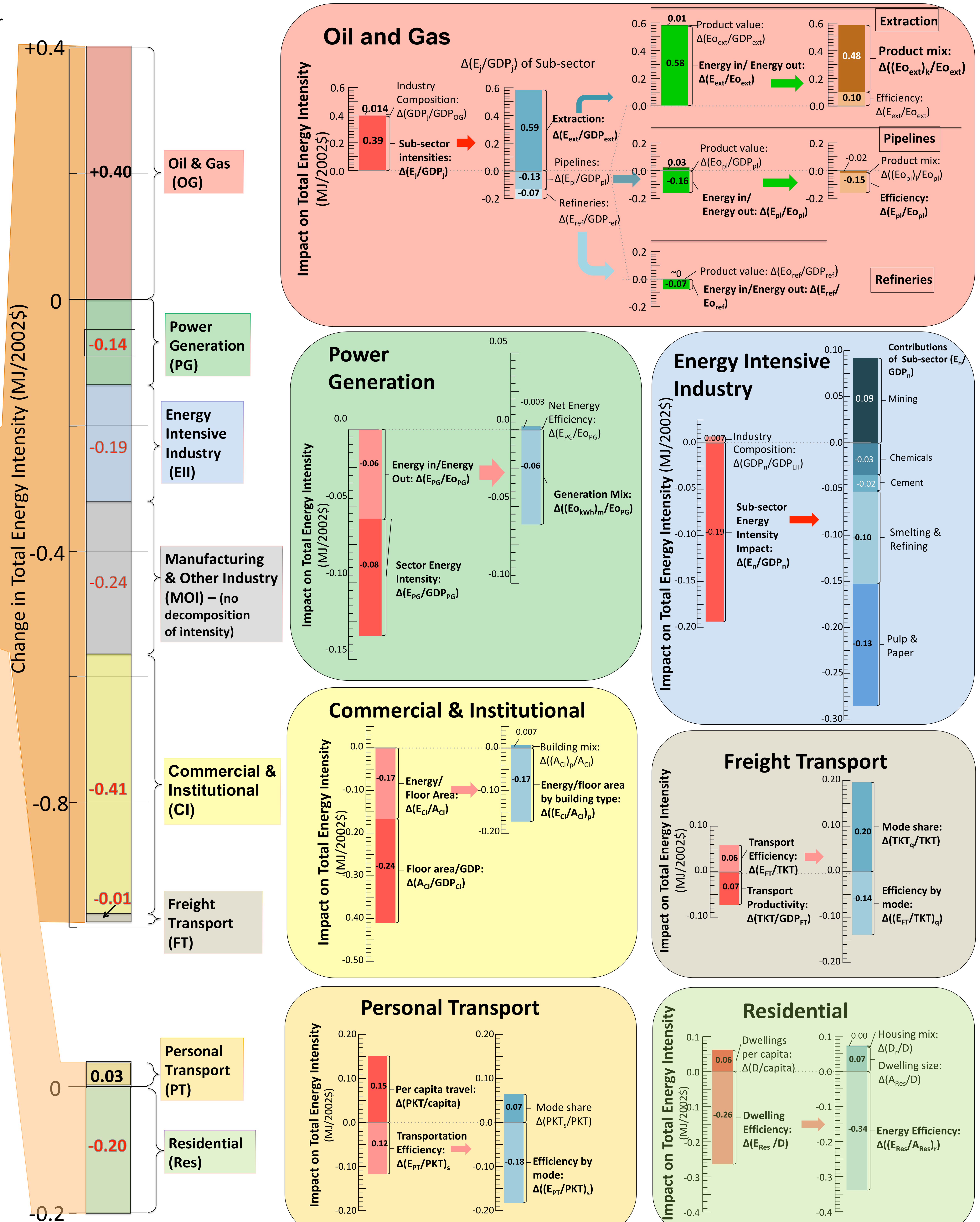
In the first stage of the analysis, we attributed Δ(E/GDP) to four factors:

- **Inter-sectoral structural change.** The six sectors of the productive economy have very different average energy intensities and so shifts in the relative contribution of each sector to total output cause aggregate E/GDP to change.
- **Business sector energy intensities.** Changes in in the energy required per dollar of output in the six defined sectors of the productive economy also impact the aggregate E/GDP ratio, according to the magnitude of the intensity change and the relative contribution of the sector to total GDP.
- **Per Capita GDP Impact**. A third of Canada’s fuel and electricity use is used by the household sector, for which intensity is defined on a per capita basis and is linked to the global E/GDP analysis by GDP/capita. For this energy use, changes in per capita GDP translate into changes in energy use per GDP.
- **Household energy intensity.** Changes in per capita fuel and electricity in residences and for personal transportation directly impact aggregate E/GDP.

In the second stage of the analysis, we defined “physical activity drivers” for each sector (e.g. floor area for commercial buildings, tonne-km of goods movement for freight). This allowed decomposition analysis of the second and fourth factors listed above – the sector intensity changes – to separate the physical energy intensity (energy efficiency) impacts from intensity impacts caused by structural changes occurring inside the defined sectors.

This comprehensive, tiered and internally consistent decomposition method allows us to summarize the extent of which E/GDP changed due to energy efficiency vs. inter-sectoral and intra-sectoral structural factors.

- RESULTS -



- DISCUSSION / CONCLUSION-

Fully 71% of the 2.64 MJ/$ decline in E/GDP between 1995 and 2010 resulted from changes in the sectoral shares of GDP (-1.27 MJ/$ impact), combined with the per capita GDP impact (-0.62 MJ/$). The remaining 29% was the result of changes in the energy intensities of the six business sectors (-0.58 MJ/$) and two household sectors (-0.17 MJ/$) analyzed. (Fig. 1)

The sector intensity declines were not simply energy efficiency improvements, but the result of often countervailing trends in energy efficiency and intra-structural effects, as shown in the figure below:

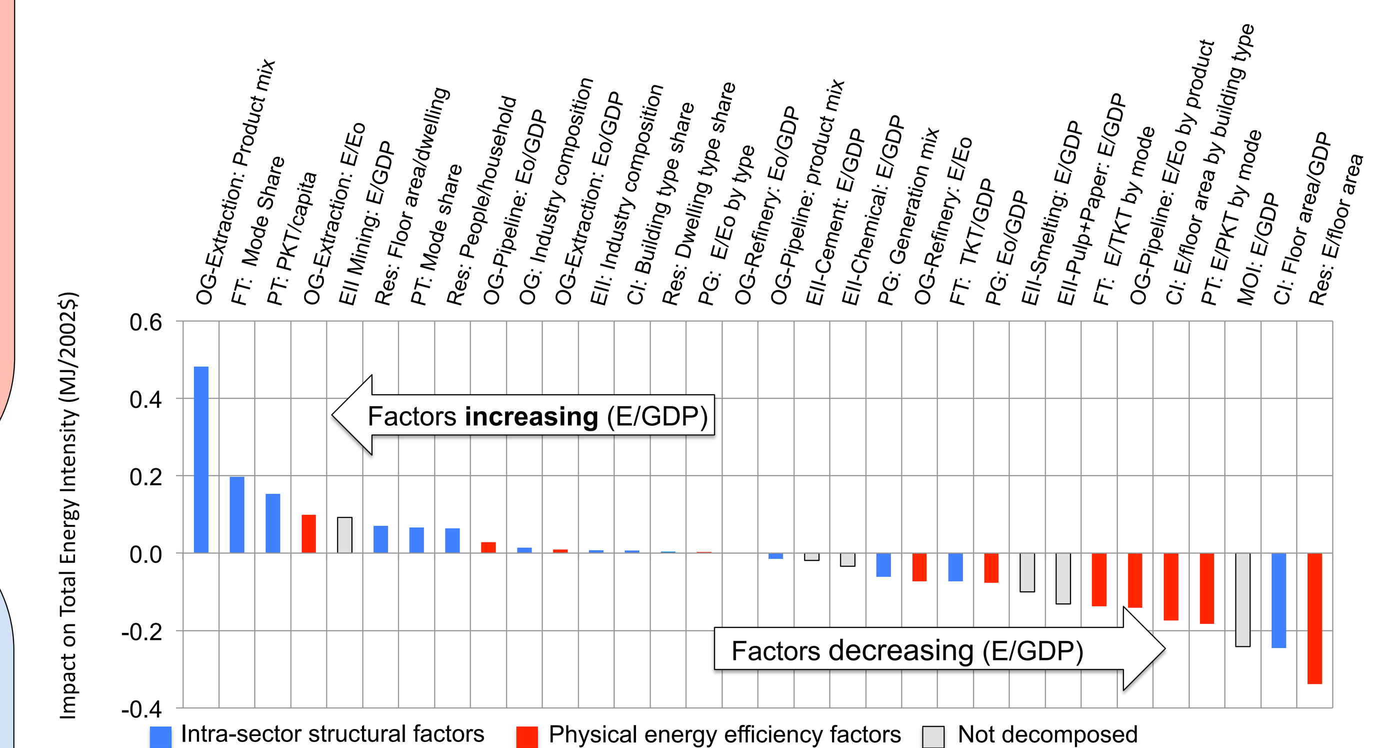
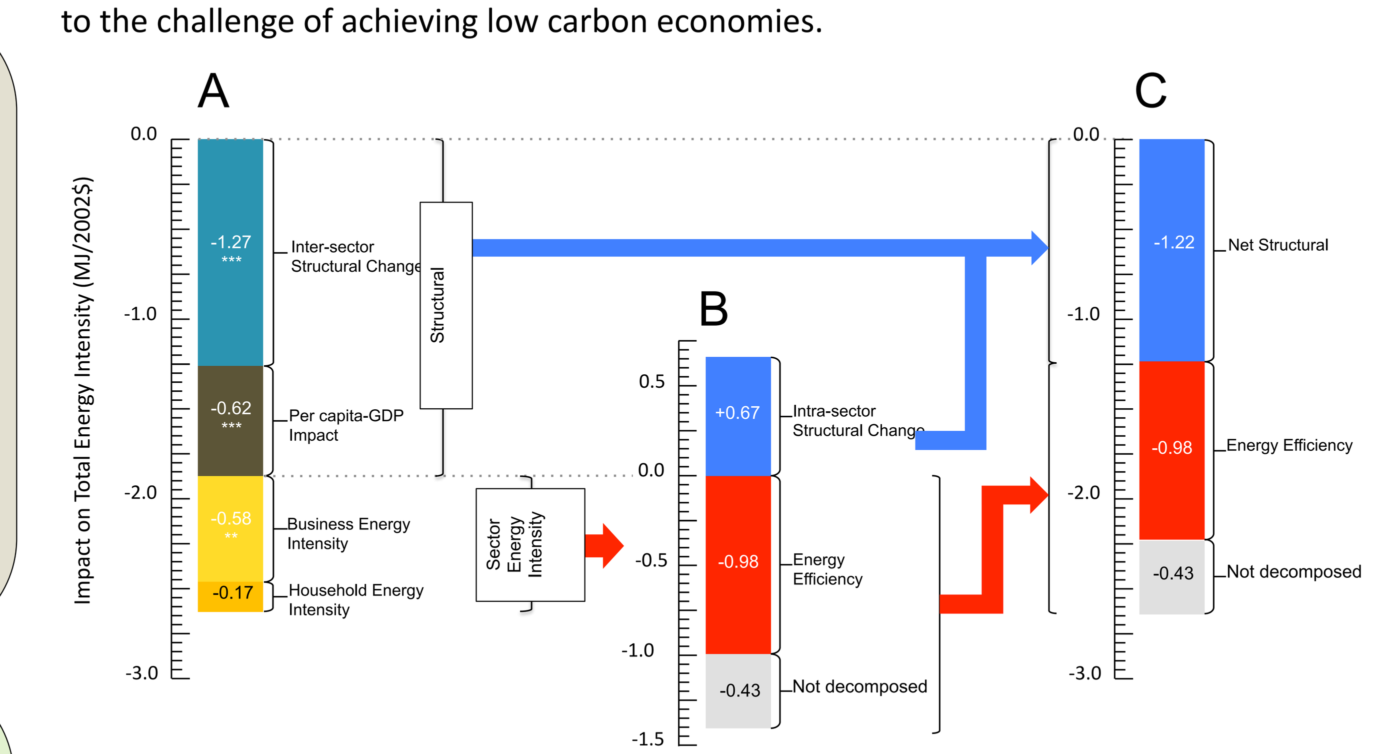


Figure 2. Decomposition of the -0.75 MJ/$ impact on Δ(E/GDP) of changes in sector energy intensities from 1995-2010 identifies 32 contributing factors reflecting a combination of intra-structural (blue), energy efficiency (red) and undetermined (grey) causes.

Unlike the larger inter-sectoral and per capita GDP impacts, which are the major reasons for the decline in E/GDP over the 1995-2010 period, the net impact of the intra-sectoral factors (blue bars in Fig. 2) was to offset some of the energy efficiency gains (red bars in Fig. 2). However, while the net impact of intrasectoral structural factors was a 0.67 MJ/$ increase in aggregate E/GDP, the higher level structural factors operating over the same time period were nearly three times larger and pushed E/GDP down by 1.89 MJ/$.

By extending the LMDI method the sector and sub-sector level in a computation framework that is nested within the first order analysis, we have produced a comprehensive, multi-level decomposition analysis of Δ(E/GDP) that sheds new light on the inter-play of structural and efficiency factors in determining the level and pattern of fuel and electricity use. The method can be applied to energy forecasting, climate change policy development, and strategic market research to better understand the dynamics of the energy system. Further refinements and extensions of this approach are recommended to support the broad scope of emission reduction strategies that will be necessary to respond to the challenge of achieving low carbon economies.



- REFERENCES -

[1] B.W. Ang, 2005 “The LMDI approach to decomposition analysis: a practical guide”, Energy Policy 33 (2005) 867-871.

[2] CanESS v6 from whatIf? Technologies Inc, Ottawa, ON

- ACKNOWLEDGMENTS -

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